DOCTOR
OF
PHILOSOPHY

MODELING REDUCED HUMAN PERFORMANCE AS A COMPLEX ADAPTIVE SYSTEM

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Current cognitive models not only lack flexibility and realism, they fail to model individual behavior and reduced performance. This research analyzes current cognitive theories (namely, symbolism, connectionism, and dynamicism). It hypothesizes that reduced human performance can be best modeled as a complex adaptive system.

The resulting multi-agent model "Reduced Human Performance Model (RHPM)" implements reactive agents competing for cognitive resources. Lack of resources is used to trigger the simulation of imperfect perception and imperfect cognition.

The simulation system is calibrated with human experimental data in scenarios involving vigilance decrement, wherein vigilance is decreased during the first 30 minutes of a screening task. RHPM is then validated against previous unknown vigilance task scenarios.

RHPM generates realistic reduced human performance with a new cognitive modeling hypothesis. The developed multi-agent system generates adaptive and emergent behavior. Its use for computer generated forces (i.e. radar screen operator) would improve the realism of simulation systems by adding human like reduced performance.

The main contribution of this research is the development of a well suited tool to mediate between vigilance theories such as signal detection theory and experimental data. It generates insights, creating likely hypotheses to improve the theories.

KEYWORDS: Vigilance, Cognitive Modeling, Complex Adaptive System, Human Performance, Personality, Cognitive Psychology

SENSITIVITY OF A NAVY REGIONAL OCEAN MODEL TO HIGH-RESOLUTION ATMOSPHERIC MODEL AND SCATTEROMETER WIND FORCING

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As the focus of Navy attention shifts to littoral regions, higher resolution and re-locatable nested models have been developed to improve shallow-water operations for ocean prediction. One of the scientific and technical challenges is to determine accuracy of ocean models on high-resolution grids needed to meet operational requirements for ocean prediction. A series of 14-day experiments are performed to evaluate

the sensitivity of a regional ocean model to low-resolution Navy Ocean Global Atmospheric Prediction System (NOGAPS) versus high-resolution Coupled Ocean Atmospheric Model Prediction System (COAMPS) wind forcing that includes scatterometer data from synthetic QuikSCAT (quick scatterometer mission) observations. Atmospheric model wind stress/wind stress curl and Pacific West Coast ocean model (PWC) surface and subsurface current/temperature model results are compared and analyzed. The results show that there is significant sensitivity in sea surface current and wind stress variability to the choice of atmospheric model grid resolution and the insertion of high-resolution satellite data. In coastal areas, increasing atmospheric model resolution produces a finer depiction of the variability observed near capes and promontories. Insertion of QuikSCAT data produces a statistical difference but no significant difference in the model fields. The ocean model runs have the expected climatological features and variability. The higher wind stress in COAMPS causes the ocean model to predict higher velocity currents and better-defined eddies near capes and promontories. However, comparisons to observations show that using models with the same high-resolution for all regions may not be an efficient use of computer resources.

KEYWORDS: Sigma Coordinate Model, NOGAPS, COAMPS, Scatterometer, High-resolution

EVOLVING A SIMULATION MODEL PRODUCT LINE SOFTWARE ARCHITECTURE FROM HETEROGENOUS MODEL REPRESENTATIONS

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National- and Department-level decision-makers expect credible Department of Defense models and simulations (M&S) to provide them confidence in the simulation results, especially for mission-critical and high-risk decisions supporting national security. Many of these large-scale, software-intensive simulation systems were autonomously developed over time, and subject to varying degrees of funding, maintenance, and life-cycle management practices, resulting in heterogeneous model representations and data. Systemic problems with distributed interoperability of these non-trivial simulations in federations' persist, and current techniques, procedures, and tools have not achieved the desired results. The Software Architecture-Based Product Line for simulation model representations, employing Architecture Readiness Levels presented in this dissertation provides an alternative methodology. The proposed four-layered M&S software architecture-based product line model enables the development of model representations supported by readiness levels. Each layer reflects a division of the software architecture-based product line. The layer represents a horizontal slice through the architecture for organizing viewpoints or views at the same level of abstraction, while the software architecture-based product line represents a vertical slice. A layer may maintain multiple views and viewpoints of a software architecture-based product line. A Domain Metadata Repository prescribes the interaction between layers. The Domain Integrated Product Development Team concept is introduced.

KEYWORDS: Model and Simulation, Software Architecture, Product Lines, Architecture Description Languages, ADL, Extensible Markup Language, XML, Verification, Validation, Readiness Levels, Interoperability, Heterogeneous Model Representations, Heterogeneous Data, Credibility, Confidence, Distributed Development